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Policy Options to Strengthen São Tomé and Príncipe's Resilience to Natural Disasters

Sneha Agrawal, Julia Bersch, Azar Sultanov, and Ke Wang

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ABSTRACT: São Tomé and Príncipe is highly vulnerable to natural disasters and strengthening resilience is macro-critical. The government faces significant challenges, including weak infrastructure, insufficient protection against floods, and lack of financial resources. Simulations using the DIGNAD model illustrate the positive impact of investing in climate-resilient infrastructure and strengthening public investment efficiency on economic growth and debt, compared to ex-post disaster management and financial contingency funds. Given São Tomé and Príncipe's large needs and debt vulnerabilities, international financial support is key to strengthen resilience.

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DEMOCRATIC REPUBLIC OF SÃO TOMÉ AND PRÍNCIPE

SELECTED ISSUES

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Approved By
The African Department

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POLICY OPTIONS TO STRENGTHEN SÃO TOMÉ AND PRÍNCIPE'S RESILIENCE TO NATURAL DISASTERS[1]

São Tomé and Príncipe's is highly vulnerable to natural disasters and strengthening resilience is macro-critical. The government faces significant challenges, including weak infrastructure, insufficient protection against floods, and lack of financial resources. Simulations using the DIGNAD model illustrate the impact of investing in climate-resilient infrastructure and strengthening public investment efficiency on economic growth and debt, compared to ex-post disaster management and financial contingency funds. Given São Tomé and Príncipe's large needs and debt vulnerabilities, international financial support is key to strengthen resilience.

A. São Tomé and Príncipe's Vulnerability to Natural Disasters

1. São Tomé and Príncipe is a small island state comprising two islands and several islets. The climate is humid tropical with two seasons, the rainy season with frequent rainfall (around September to May) and the dry season (*Gravana*) with lower temperatures (around June to August). Average temperatures are relatively stable throughout the year, while there are large differences in rainfall between different parts of the country, determined by the location of the mountains.

2. São Tomé and Príncipe is highly vulnerable to natural disasters and the impact of climate change. This is mainly due to its insularity and small territory, as well as its fragile ecosystems and the exposure of its natural resources to human pressure. Furthermore, most people live along the coast and near rivers, where also most physical assets are located. The main climate hazard for São Tomé and Príncipe is floods, followed by landslides which are often secondary effects of floods, and floods result mainly from heavy rains.[2]

3. Quantifying São Tomé and Príncipe's exposure and vulnerability to natural disasters is challenging, due to weak or non-existent data. The most significant natural disaster in recent years occurred between December 2021 and February 2022, when floods triggered by intense rainfall caused significant damage, estimated at around 6 percent of GDP.[3] According to a World Bank study (2024), the rainfall event that caused these severe floods occurs, on average, once every 20 years in São Tomé and Príncipe.[4] It also finds that the country's flood risk profile is relatively flat, without large differences between annually recurring floods and those occurring every 50 or 100 years. The country experiences floods on an annual basis and even minor floods can have a large impact, as the population and assets are concentrated in relatively small coastal areas and infrastructure is very weak (and hence susceptible). Also, there are very limited flood protection

[1] Prepared by Sneha Agrawal, Julia Bersch, Azar Sultanov, and Ke Wang.

[2] See, e.g., WB (2024), Sao Tomé-et-Principe | GFDRR, and Sao Tome and Principe - Vulnerability | Climate Change Knowledge Portal.

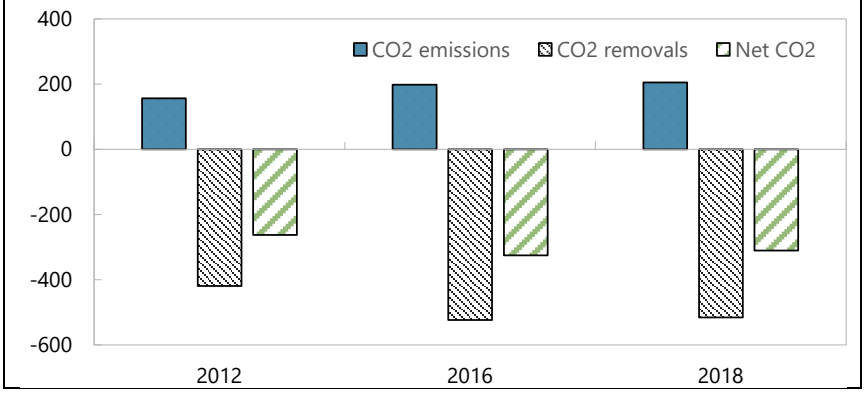
[3] See 2022 Article IV staff report.

[4] See also Rising Waters, Rising Hopes: Shaping Resilience in São Tomé and Príncipe Through Flood Risk Analysis.

measures such as levees and dunes, even to protect against recurring annual floods. According to the World Bank, São Tomé and Príncipe ranks among the most vulnerable countries to climate change due to its unique geography, fragile ecosystems, and low socioeconomic development.[5] Climate change impacts the country mainly through higher temperatures, increased precipitation, rising sea levels, advancing coastal erosion which can increase the risk of flooding, and extreme weather events. The World Bank is currently working on its first Country Climate and Development Report (CCDR) for São Tomé and Príncipe, an important diagnostic tool, which is expected to be completed in 2026. The CCDR is expected to help prioritize the most impactful actions to boost adaptation and resilience and reduce greenhouse gas emission, while delivering on broader development goals.[6]

4. As a full member of the United Nations Framework Convention on Climate Change (UNFCCC) São Tomé and Príncipe is committed to reduce its greenhouse gas emissions (GHG) by 27 percent by 2030 compared to a business-as-usual scenario. While the country's emissions are negligible in international comparison, the authorities still aim at improving their overall emission balance as part of their Nationally Determined Contributions (NDC).[7] Through 2018 (latest year with available data), the energy sector was the country's largest emitter, followed by the agriculture and waste sectors. At the same time, the "forest and other land uses" sector worked as CO2 sequester, more than compensating for the CO2 emissions of other sectors, making São Tomé and Príncipe on balance a net carbon sink.[8] In their 2021 NDC, the authorities target a reduction in GHG by 27 percent by 2030, with an estimated total cost of around US$150 million. This nearly doubles the 2015 GHG reduction target, with a focus on forestry, energy, transport, and industrial sectors.

Figure 1. São Tomé and Príncipe: Evolution of CO2eq Emissions
(In Gigagrams)



5. To achieve the targeted emission reduction, São Tomé and Príncipe will promote the use of renewable energy, improve energy efficiency, and implement sustainable land management practices. In addition to mitigation, the 2021 NDC emphasizes the importance of adaptation measures to cope with the impact of climate change, particularly in vulnerable sectors such as coastal zones, agriculture, and water resources. Key adaptation actions include improving disaster risk management, developing early warning systems, and enhancing climate resilience

[5] See https://storymaps.arcgis.com/stories/2b69b33c3c75482b86ec985e1dca6f49.

[6] See Country Climate and Development Reports (CCDRs).

[7] See São Tomé and Príncipe (2021).

[8] See São Tomé and Príncipe (2021).

across various infrastructure and social systems. São Tomé and Príncipe is seeking international support and financing to meet its climate goals, acknowledging the challenges it faces as a small island developing state. In its first biannual update report (BUR) in 2022, São Tomé and Príncipe provided details on mitigation measures, the national monitoring, reporting, and verification (MRV) system, and highlighted the country's capacity and financial needs to effectively report emissions, aiming to support climate-resilient development and demonstrate the positive impact of mitigation and adaptation actions.[9] The authorities recently presented an action plan for the decarbonization and resilience of the energy sector (PADRES), which outlines steps to move away from fuel-based electricity production towards renewables.[10]

6. The country has adjusted it institutional set-up to better coordinate policy action.[11] The General Directorate for the Environment (DGA), under the Ministry of Infrastructure, Natural Resources and Environment, was created in 2007 and is responsible for the execution and coordination of policies and government strategies on the environment. The National Institute of Meteorology is responsible for recording and disseminating climate data. In 2011, the National Council for Disaster Preparedness and Response (CONPREC) was established to coordinate disaster risk management activities. In 2012, the National Committee for Climate Change was created to coordinate, manage, train and raise awareness among stakeholders in São Tomé and Príncipe. The authorities have also prepared a Contingency Plan for Natural Disasters (2016-2020), a National Strategy for Disaster Risk Management (last updated in 2016), and a Multisectoral Investment Plan for coastal zone management. A draft disaster risk management law is under consideration, which would introduce an early warning system, assign responsibilities, and have a color-coded alert system. While São Tomé and Príncipe has disaster preparedness and response plans at the national level, the country is working with the World Bank to expand them to the local level.

7. Reducing the country's vulnerability to the impact of natural disasters will depend on climate adaptation actions. These include developing green and grey coastal infrastructure, improving early warning systems, and promoting planned relocations. The authorities aim at reducing climate-related risks and increase the resilience of communities and sectors by strengthening technical and institutional capacities, mainstreaming climate resilience into national and subnational planning and budgeting, and undertaking investments.[12] In June 2022, São Tomé and Príncipe's government, in collaboration with UNEP, launched a process to develop a National Adaptation Plan (NAP), a 42-month project funded by the Green Climate Fund (over US$2.9 million).[13] Work on the NAP is ongoing.

[9] See São Tomé and Príncipe (2022).

[10] See, e.g., Decarbonization in small island developing states?

[11] See, e.g., São Tomé and Príncipe (2021 and 2022) and the World Bank's GFDRR.

[12] See São Tomé and Príncipe (2021).

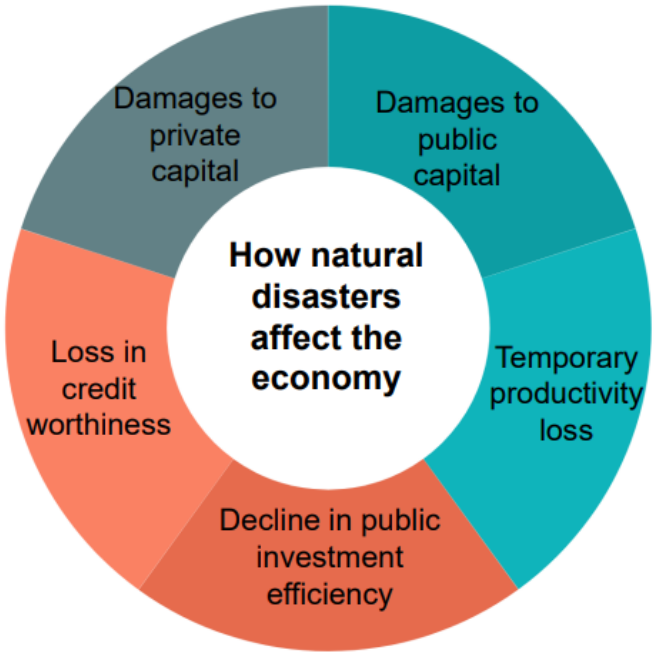
[13] See São Tomé and Príncipe develops National Adaptation Plan for climate change | Global Adaptation Network (GAN).

8. The World Bank is supporting São Tomé and Príncipe in strengthening its coastal resilience, adaptation and resilience to floods. This is financed through the West Africa Coastal Areas (WACA) Management Program, with financial resources of US$15 million over 5 years, allocated mainly for physical investment, including relocation of people to safe expansion zones (see World Bank, 2023). With World Bank support, São Tomé and Príncipe is also strengthening its early warning system, which monitors weather and hazards, prepares forecasts, and disseminates information.

B. Application of the DIGNAD Model and Scenario Analysis

9. The Debt, Investment, Growth, and Natural Disasters (DIGNAD) model is a dynamic general equilibrium model designed to analyze the impact of investing in climate-resilient capital on economic growth and debt sustainability under various scenarios. The DIGNAD model (Marto, Papageorgiou and Klyuev, 2018) is an extension of the DIG (Debt, Investment and Growth) model of Buffie and others (2012), which has been developed in the Research Department and used at the IMF for many years. In the DIGNAD model natural disasters can affect the economy through five channels: (i) damages to public capital; (ii) damages to private capital; (iii) a temporary productivity loss; (iv) reduced public investment efficiency; and (v) a loss in creditworthiness. Additionally, it assesses debt sustainability risks following a natural disaster and evaluates the effects of ex-ante policies, such as investing in climate-resilient infrastructure (versus non-resilient infrastructure) and building fiscal buffers. The model also considers public investment inefficiency and limitations posed by absorptive capacity constraints. The model captures the challenges of closing infrastructure gaps in developing countries that frequently face natural disasters and captures the linkages among public investment, growth, and debt, such as the investment-growth nexus, the fiscal adjustment, and the private sector response.

Figure 2. Natural Disasters in the DIGNAD Model



10. The risk of a natural event turning into a disaster depends not only on the force of the natural event, but also on the quality of infrastructure and existing structures for rapid responses and assistance in an emergency. The more fragile a country's infrastructure and the poorer its access to public services, such as health care, the more susceptible a country is to natural events. São Tomé and Príncipe is highly exposed to natural hazards, its infrastructure and public service provision are fragile, and fiscal space is highly constrained in undertaking needed investment.

Table 1. São Tomé and Príncipe: Calibrated Parameters and Initial Values
(In Percent)

Definition	Value
Grants to GDP ratio	7.8
Domestic public debt to GDP ratio	42.8
Concessional public debt to GDP ratio	59.2
External commercial public debt to GDP ratio	12.3
Return to standard infrastructure	30.0
Return to climate-resilient infrastructure	40.0
Public standard infrastructure investment to GDP ratio	6.0
Depreciation rate of standard public infrastructure	7.5
Depreciation rate of resilient public infrastructure	3.0
Public investment efficiency	50.0

Source: IMF staff calculations.

11. The model is tailored to São Tomé and Príncipe's economy. The model's steady state aligns the level of standard capital infrastructure investment with projected values for 2025-28, amounting to about 6 percent of GDP and public investment efficiency is set at 50 percent based on the average value in sub-Saharan Africa. The initial domestic public debt value is calibrated using the 2023 value of 42.8 percent of GDP.[14] The parameters defining the standard and resilient infrastructure are in line with Marto, Papageorgiou and Klyuev (2018) and, in the absence of specific information, the parameters of the average LIC in their model were used.

12. To illustrate the macro-fiscal implications of climate change adaptation and reforms for São Tomé and Principe, a natural disaster is simulated to occur under the following three simulation sets with three scenarios each.[15] Across all scenarios, the model is calibrated to reflect the state of the economy in 2024 (starting point), followed by a simulated natural disaster occurring in 2029, specifically focusing on the macroeconomic effects of one-time flooding on the islands.[16] Each simulation provides insights into potential policy options for São Tomé and Principe in response to natural disasters and their implications.

13. Simulation 1 (Figure 3) evaluates the role of adaptation investment in climate-resilient infrastructure and its scalability vis-à-vis a baseline scenario of no intervention in response to the disaster.

[14] This debt definition is aligned with the DSA.

[15] The analysis is conducted using the DIGNAD toolkit by Aligishiev, Ruane, and Sultanov (2023).

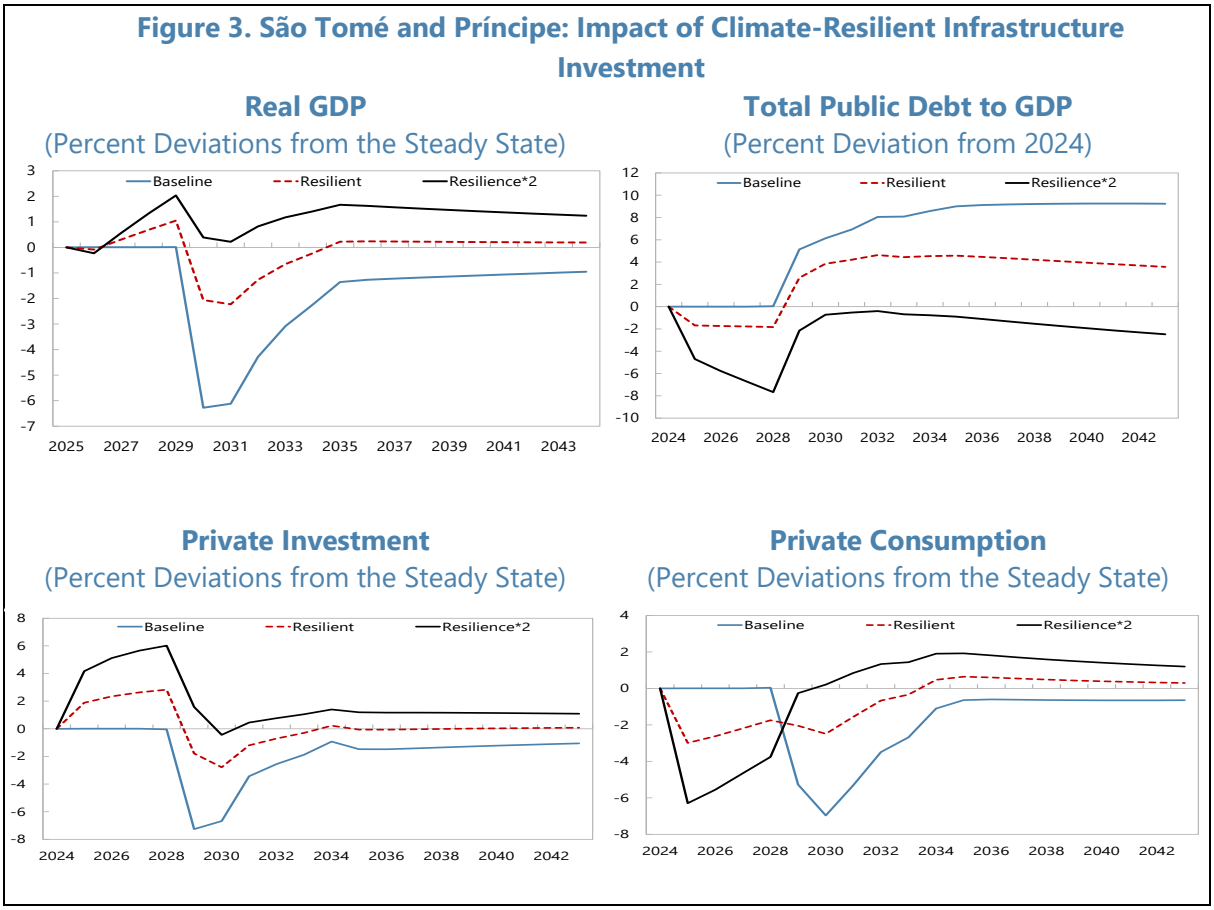
[16] The calibration assumes a one-off 6 percent point GDP loss, somewhat larger than in recent historical data, but aligned with the damage from flooding STP might experience in the future.

- Scenario 1.1. The **baseline scenario** assumes no resilient infrastructure investment by the authorities. A natural disaster is assumed to hit the economy in 2029; the subsequent post-disaster recovery starts right away and spans the next five years. Following a natural disaster, both the government and the private sector need to restore the public and private capital stocks, respectively, since economic activity depends on the infrastructure. To capture the impetus for a swift recovery, we assume that the government rebuilds its damaged infrastructure to its pre-disaster level in about five years. The government can resort to several instruments to finance post-disaster reconstruction, including with debt (domestic, external commercial, or external concessional), grants, or by mobilizing additional domestic revenue. The baseline scenario assumes that the recovery is financed in equal parts with domestic debt and external commercial borrowing.

- Scenario 1.2. The **resilient infrastructure investment scenario** assumes that the authorities invest 2 percent of GDP per year in climate-resilient public infrastructure in 2025-28. The financing is equally split between grants and concessional loans. Assumptions about the disaster and recovery are the same as in the baseline scenario.

- Scenario 1.3. The **resilience scaling-up scenario** illustrates the scalability of the positive impact from increasing climate-resilient infrastructure investment to 4 percent of GDP per year in 2025-28. The additional public investment is assumed to be fully financed with grants, so that the overall financing mix consists of ¾ grants and ¼ concessional loans.

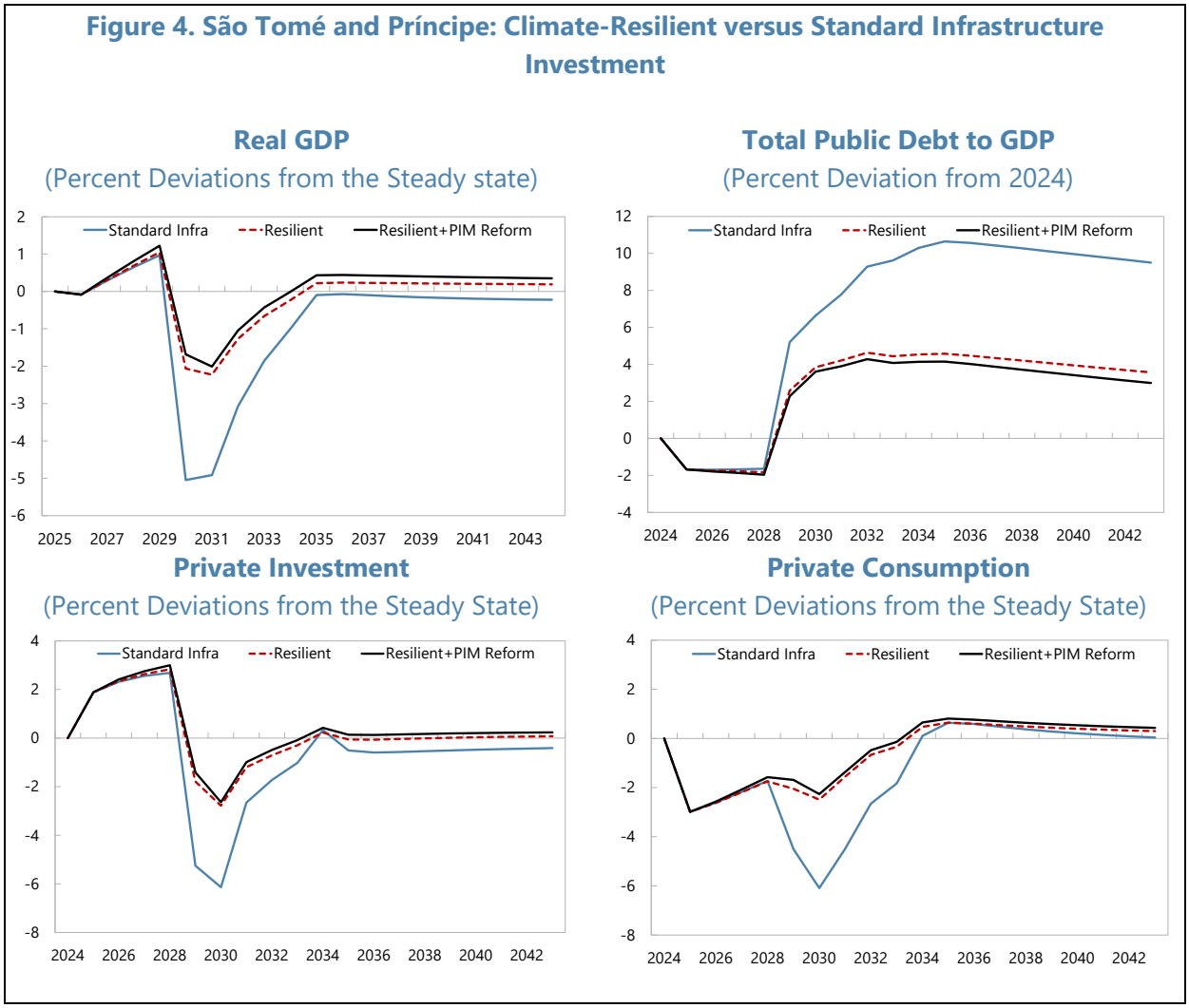
Figure 3. São Tomé and Príncipe: Impact of Climate-Resilient Infrastructure Investment



14. Simulation 2 (Figure 4) illustrates the advantages of resilient infrastructure investment compared to standard investment, as well as the impact of increased public investment efficiency (e.g., from strengthening public investment management).

- Scenario 2.1. The **standard infrastructure scenario** assumes public investment in standard infrastructure of 2 percent of GDP per year in 2025-28. The financing is equally split between grants and concessional loans. A natural disaster is simulated to occur in 2029.
- Scenario 2.2. The **resilient infrastructure investment scenario** is the same as scenario 1.2 and compared to scenario 2.1 replaces standard investment with climate-resilient one.
- Scenario 2.3. The **resilient investment plus PIM reform scenario** showcases the impact from reforms to strengthen public investment efficiency by 10 percentage points, in addition to investing in climate-resilient infrastructure. Everything else remains the same as in scenario 2.2.

Figure 4. São Tomé and Príncipe: Climate-Resilient versus Standard Infrastructure Investment



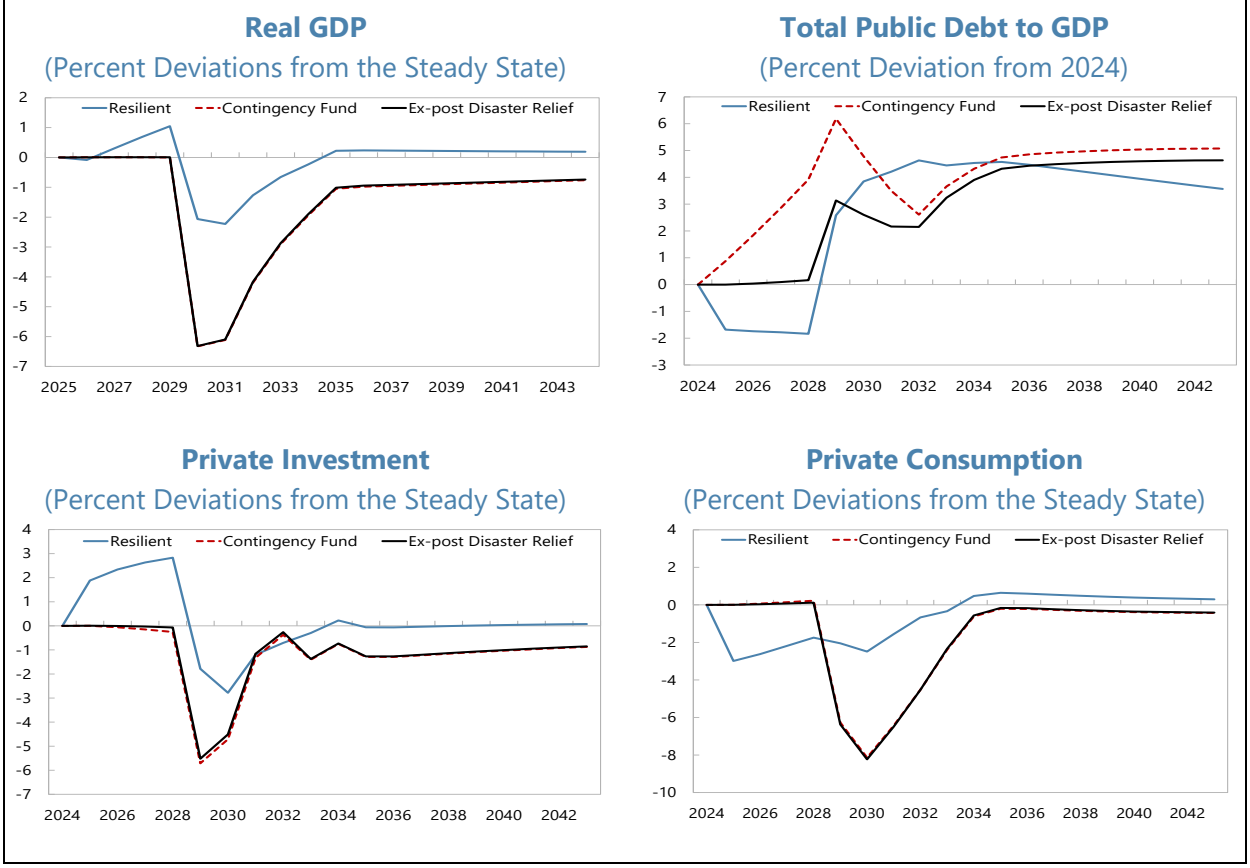
15. Simulation 3 (Figure 5) illustrates the trade-offs between ex-post disaster management and ex-ante disaster preparedness using financial insurance or resilient infrastructure investment.

- Scenario 3.1. The **ex-post disaster management scenario** assumes that a natural disaster hits the economy in 2029 and the subsequent recovery requires investment spending of 2 percent of GDP per year in 2029-2032. The financing is assumed to be equally split between grants and concessional loans.

- Scenario 3.2. The **ex-ante disaster preparedness scenario** assumes that a natural disaster contingency fund is set up, in which the authorities invest 2 percent of GDP per year during 2025-28. The funding is split equally between grants and concessional loans. Once the disaster hits in 2029, the authorities draw down this fund at a rate of 2 percent of GPD per year in 2029-32.

- Scenario 3.3. The **resilient infrastructure investment scenario** is the same as scenario 1.2. with ex-ante public investment in climate-resilient infrastructure. Compared to scenario 3.2, the same amount of resources is invested in physical infrastructural rather than in a financial contingency fund.

Figure 5. São Tomé and Príncipe: Alternate Financing Options and Timelines for Disaster Management



16. The DIGNAD simulations illustrate how investing in climate-resilient infrastructure (Figure 3) and strengthening public investment efficiency (Figure 4) could increase São Tomé and Príncipe's resilience to natural disasters. The effects operate through the following channels:

- *Public and private investment*. In the baseline scenario the output drop is substantial when the disaster hits the economy and GDP recovers slowly, but even years after the disaster it remains below where it would have been in the absence of a disaster. This slow recovery is due to the fact that even though the government rebuilds public infrastructure within five years after the disaster, it takes many years for the private sector to rebuild the private capital stock due to adjustment costs, which introduces a scarring effect from natural disasters. Relative to the baseline, the pre-disaster scaling up of public investment crowds in private investment and increases output in all scenarios but at different scales. The increase is larger for resilient than standard investment because resilient capital has higher returns, depreciates more slowly, and crowds in more private capital.

- *Growth and its drivers*. When a natural disaster hits, it reduces output in the short term under all scenarios reflecting (i) permanent damages to public infrastructure; (ii) permanent damages to private capital; and (iii) temporary losses of productivity. The GDP decline is highest under the baseline scenario, at 6.3 percentage points, relative to the steady state, compared to about 5 percentage points in the case of standard infrastructure and 2.3 percentage points under the resilient infrastructure scenario. This is because the latter is characterized by greater durability and greater resilience, in that it suffers smaller damages in the aftermath of disaster shocks as well as mitigates damages to standard public infrastructure. Private investment is also more resilient under the resilient infrastructure scenario vis-à-vis both baseline and standard infrastructure scenarios because climate-resilient capital raises returns to private investment, and spurs growth. In scenario 2.3 (with higher public investment efficiency) GDP and private investment increase more pre-disaster than in the other scenarios because higher public investment efficiency means that with the same resources more can be built. This also implies that the post-disaster recovery costs are lower. Over the long run, GDP in the scenario with climate-resilient investment and higher public investment efficiency stabilizes at a higher level compared to other scenarios due to crowding in private investment, higher productivity, and a mitigated impact of natural disasters.

- *Public debt*. A natural disaster increases the fiscal deficit due to reconstruction costs, regardless of the type of infrastructure, though the size of the increase differs. With climate-resilient infrastructure, damages and hence repair costs are lower, which leads to a lower fiscal deficit and the debt increase is more contained after the disaster strikes. Moreover, unlike the standard investment scenario, the debt level stabilizes more quickly over the medium- and long-term due to smaller and less-persistent output losses and smaller reconstruction needs (Figure 3). Consequently, in relative terms, resilient infrastructure is associated with lower public debt in the long-term compared to the baseline and standard infrastructure scenarios. With higher public investment efficiency, less spending is required to finance the disaster recovery, yielding even more favorable debt dynamics.

- *Private consumption*. Investment in both types of infrastructure crowds-in private investments (varying based on the respective returns), impacting also private consumption during the pre-disaster period. However, results indicate that the decline in private consumption following the shock is less pronounced in the resilient infrastructure scenario compared to the baseline and standard infrastructure investment scenarios. This demonstrates that maintaining high levels of resilient capital ultimately yields benefits, resulting in a swift recovery and even a rebound in private consumption that exceeds pre-disaster levels.

17. The DIGNAD simulation 3 (Figure 5) results imply that investing in resilient infrastructure is better than both ex-post disaster management and ex-ante disaster preparedness via a financial contingency fund. The timing of financial inflows has no impact on GDP growth, private investment or private consumption, unless they are invested into real capital/infrastructure (monetary neutrality). Hence, the real impact of ex-post disaster management using grants and concessional loans is identical to the ex-ante use of similar financial resources to accumulate a contingency fund to finance the recovery. By contrast, using the same amount of money to build climate-resilient infrastructure leads to better outcomes for GDP growth, private investment, and private consumption in the short- and long-run. Moreover, climate-resilient infrastructure lowers disaster losses and damages and, thereby, repair costs, contributing to lower public debt over the long term.

C. Conclusion and Policy Recommendations

18. The DIGNAD simulations illustrate that climate-resilient public investment could increase São Tomé and Príncipe's resilience to natural disasters. While extreme natural disasters cannot be prevented, their negative impact can be contained by making infrastructure more resilient and strengthening disaster preparedness more generally. Countries that invest in resilient infrastructure, install, and use early warning systems, and invest in climate and environmental protection are better prepared to deal with natural disasters. Therefore, it is important to secure grants and concessional financing for resilient infrastructure and adaptation plans. Strengthening public investment management will also help ensure more efficient use of limited resources, maximizing their impact. Accelerating the preparation of a National Adaptation Plan would also help by providing strategic direction.

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